

EM Field Enhancement for Array Antenna by Using the Array of EBG Cells

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ABSTRACT: In this paper the mutual coupling in array antennas where the mutual coupling resulting poor radiation efficiency is minimized with the help of a single line of EBG structure. In general each element in the array antenna produce their respective radiation and the final pattern will be the superimposition of all these individual patterns, in this process some of the components in the space wave vector of one element may cancel the neighbour element components this implies the loss of energy. Now in the current paper the problem is rectified by introducing a single line of EBG structure and the comparative analysis is illustrated in this paper.

Keywords: Array antenna, Mutual coupling, Space waves, EBG structures

I. INTRODUCTION

In the open literature so many researches are done on the meta-materials also known as the artificial magnetic conductors. Originally these are implemented to suppress the surface wave's propagation in the antennas [1]. But later these devices are utilized for several applications in wireless communications field to alter the antenna parameters without changing the antenna itself, by using these structures we can get the enhanced gain [2], bandwidth, and low return loss etc. And in the current paper the concept of surface wave suppression [8] is used for reducing the mutual coupling in the array antennas. Because these structures do not conduct AC current in the specified forbidden band. In the current paper the dipole antenna with 3 elements is taken with equal spacing and a line of EBG is place between them and the design is shown in the following figure [1].

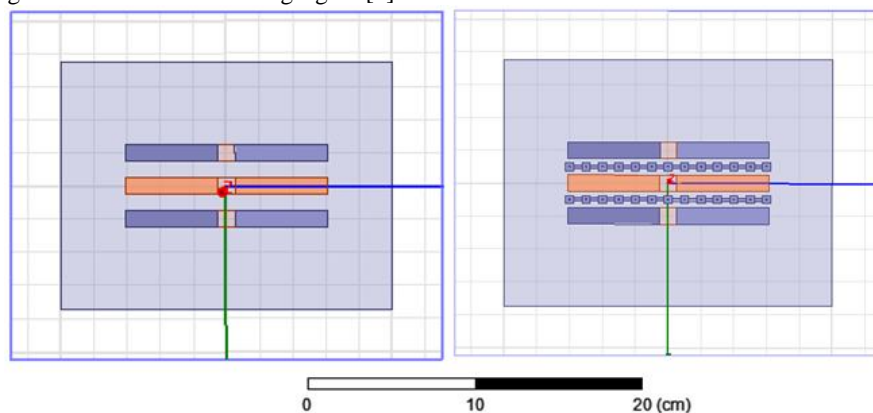


Figure [1] Designed antenna with and without EBG line

EBG Structure Explanation

The proposed mushroom-like EBG structure [3] consists of four parts: a ground plane, a dielectric substrate, metallic patches, and connecting vias. These structures have a distinct stop-band for surface-wave propagation. the operation of EBg cells can be explained by LC circuit here L is inductance due to the current flow in the via and C is capacitance due to fringing field in the gap between patches.

The L and C are determined by the following equations [4]

$$L = \mu_0 h \quad (1)$$

$$C = W \epsilon_0 (1 + \epsilon_r) \cosh^{-1}((2W + g)/g) / \Pi \quad (2)$$

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 3, March 2014

Where μ_o is the permeability of free space, ϵ_o is the permittivity of free space. W is patching width; g is gap between patches, h substrate thickness and ϵ_r is dielectric Constant.

II. SIMULATION RESULTS

A. Return loss curves

The below figure [2] represents the return loss curves comparison for the designed antenna without and with EBG lines.

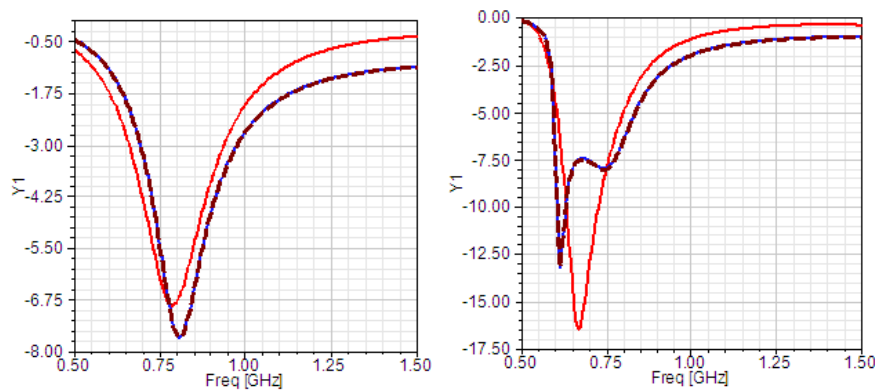


Figure [2] Return loss curves without and with EBG lines

In the above figure it is clearly seen that with little BW reduction the return loss is reduced with the introduction of the EBG structure between the array elements the three curves represents the return loss for three port excitations for 3 array elements as S11, S22 and S33.

B. E,H-fields

The E,H- fields analysis explains how much the radiation energy is improved when the low mutual coupling is obtained by the EBG line, figures [3] & [4] shows the E,H field analysis comparison. Generally when the mutual coupling is high due to the insufficient spacing between the array elements to avoid this if we increase the spacing that may resulting large size of antenna to avoid this EBG cells are used to get low mutual coupling for array antennas.

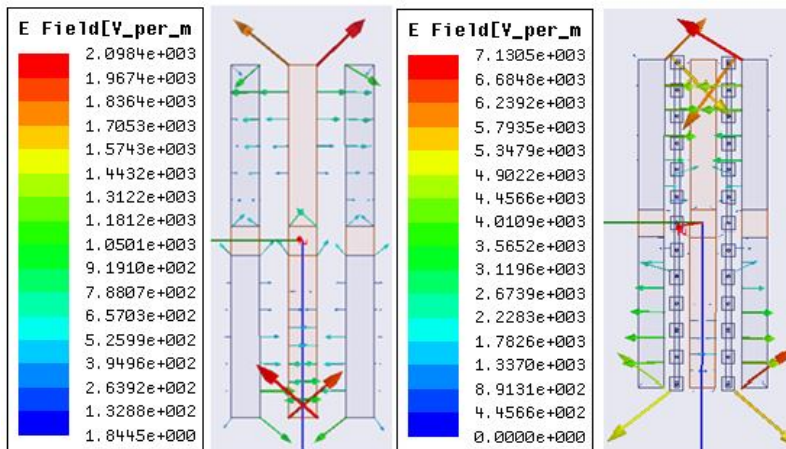


Figure [3] E- field analyses without and with EBG lines

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 3, March 2014

In the above figure [3] for the designed antenna E-field have so many low quantities around 1 and few better values 9.1910, 7.8807, 6.5703, 5.2599 and 3.9496 but when the EBG is placed in the second part expect low quantities 1.7826 and 1.3370 remaining all are high values starting from 7.1305 to 2.2283.

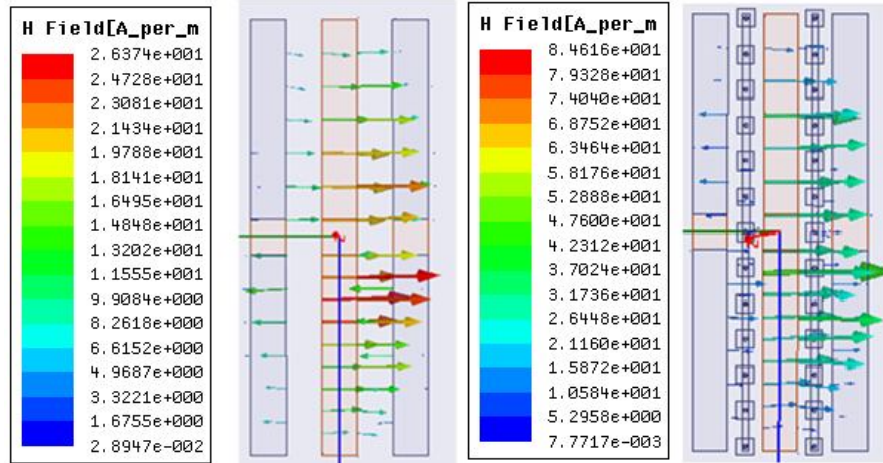


Figure [4] H- field analyses without and with EBG lines

In the above figure [4] most of the H-field analysis values are improved when the EBG lines are placed.

C. Total Gain curves

The total gain curves in 3D plots and top view are represented in the following figures [5] and [6].

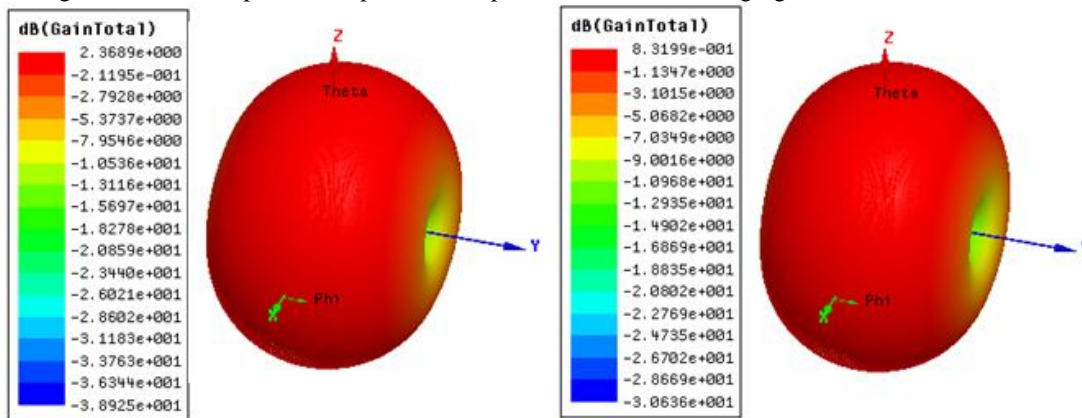


Figure [5] 3D plot of total gain comparison without and with EBG lines

In the above we figure [5] the analysed values can explains how much the radiation is improved when the low mutual coupling is obtained by using the EBG structure. In the first part of the figure the maximum gain is 2.3689dB here the curve represents the radiation in all directions and compared to this when EBG is placed the mutual coupling between the elements is reduced that in turn enhances the radiation into the surroundings and the maximum value is now 8.3199dB.

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 3, March 2014

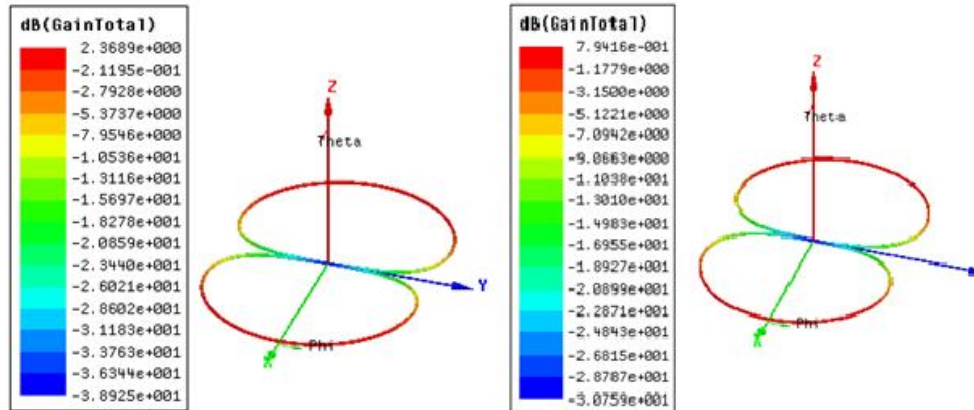


Figure [6] 2D plot of total gain comparison without and with EBG lines

The above figure compares how much the enhancement is achieved in the $\phi=90^\circ$ region it is clear that it is improved from 2.3689 to 7.9416. That explains how much the gain is improved over the array antennas without changing the spacing between the elements.

TABLE I
ANTENNA PARAMETERS

Quantity	Value	
Max U	0.00740466(W/sr)	0.0338574(W/sr)
Peak Directivity	1.5108	1.77996
Peak Gain	1.21115	1.72542
Peak Realized Gain	0.0930519	0.425475
Radiated Power	0.0615913(W)	0.239035(W)
Accepted Power	0.0768291(W)	0.246592(W)
Incident Power	1(W)	1(W)
Radiation Efficiency	0.801666	0.969354
Front to Back Ratio	1.00653	1.00907

In the above table the comparison will explain how much all parameters have been improved with the EBG structure especially the main improvement is radiation efficiency when the mutual coupling is strong for the first case where the EBG is not present the efficiency is 80.16% but when the low mutual coupling is achieved due to the EBG presence between the array elements the efficiency is increased to 96.9354%

III. CONCLUSION

In the field of antennas several techniques have been implemented to achieve low mutual coupling for array antennas and each alter the specifications of antenna a little bit. Now the current research dealt with achieving the low mutual coupling without altering antenna but simply place the EBG structure and it also deals with the problem of low spacing between the elements and the gain and radiation efficiency are improved.



International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 3, March 2014

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BIOGRAPHY



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